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Indian Standard
SPECIFICATION FOR ELECTRICAL EQUIPMENT OF MACHINE TOOLS

PART I ELECTRICAL EQUIPMENT OF MACHINES FOR GENERAL USE

(Second Revision)

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Indian Standard

SPECIFICATION FOR ELECTRICAL EQUIPMENT OF MACHINE TOOLS

PART I ELECTRICAL EQUIPMENT OF MACHINES FOR GENERAL USE

(Second Revision)

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Indian Standard

SPECIFICATION FOR ELECTRICAL EQUIPMENT OF MACHINE TOOLS

PART I ELECTRICAL EQUIPMENT OF MACHINES FOR GENERAL USE

(Second Revision)

0. FOREWORD

0.1 This Indian Standard (Second Revision) was adopted by the Indian Standards Institution on 1 November 1972, after the draft finalized by the Switchgear and Controlgear Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 Following the necessities of mass production methods, machine tools have been designed for a number of special purposes. In this process though the design of the actual machine tool has been simplified, it has resulted in the electrical control equipment becoming more complex particularly as electronic devices have been extensively adopted. Such conditions have naturally tended for the designs to be developed on almost as many lines as there were controlgear manufacturers, with the result that there are considerable maintenance difficulties because of lack of standardization so far as the positioning and installation are concerned. Furthermore, the electrical control equipment to be installed, has often been of prevalent design, more or less adopted for the machine tool concerned rather than of a form specially designed for the control of that particular machine. This standard was first brought out in the year 1959 with the object of bringing together in one document various existing requirements which directly affect machine tools. Another was to obviate the necessity for a multiplicity of specifications prepared by individual users or purchasers of machine tools. A further object was to give a lead on design which will allow adequate accessibility so that the servicing of machine tools may become easy. This second revision has been brought out to line up this Indian Standard with the latest international practice.

0.3 The purpose of this standard is to ensure the safety of personnel and equipment, uninterrupted production, facility of maintenance and adequate length of service from the equipment. It is also hoped that this standard will assist the designers of electrical equipment in further development of components and the like especially intended for the machine-tool industry.

0.4 It is universally known how high temperature, high humidity, sudden temperature changes, strong sunlight, rodents, reptiles and insects, mould growth, dust, etc, characterize tropical conditions and also the manner in which such conditions affect electrical equipment. It has, however, not been possible to lay down in precise terms the requirements that should be satisfied by the equipment in this aspect. The design of electrical equipment to be fitted into the machine tools intended for use in tropical countries should be such that it will give adequate protection under such adverse conditions.

0.5 In preparing this revision, assistance has been derived from the IEC Pub 204-1 'Electrical equipment of machine tools, Part I Electrical equipment of machines for general use' issued by the International Electrotechnical Commission.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard lays down general requirements in regard to the application of electrical components, such as control apparatus, motors, wiring, and accessories to machine tools, for connection to circuits which operate from a supply voltage up to and including 650 V, 50 Hz and higher frequencies.

Note — In case of higher frequencies all the electrical equipment shall be suitable for that frequency.

1.2 This standard applies to all electrical equipment and wiring furnished as part of a machine tool and originating at the machine-tool isolating switch. Any other necessary wiring should be installed in accordance with the requirements of the Indian Electricity Rules and any other regulations in force in the particular area.

1.3 This standard also applies to the electrical equipment of machine tools used in large series production (for example, transfer machines) and to electronic equipment as far as they are not modified by IS : 1356 (Part II)* and IS : 1356 (Part III)†.

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*Rules for rounding off numerical values (*revised*).

1.4 If the machining of certain materials is attended by special risks, additional precautions may be required. These additional precautions, however, are not covered in this standard.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Control Device — Devices such as position sensors, relays, magnetically operated valves, etc, used for controlling the operation by predetermined conditions.

2.2 Compartment — A space within an element of a machine tool in which some devices may be installed.

2.3 Control Enclosure — A protective housing for the electrical apparatus whether mounted separately from the machine tool or mounted on the machine tool.

2.4 Control Circuit — Circuit used for the operational control of the machine tool and for protection of the power circuits.

2.5 Conduit — A Tubular raceway. The conduit is either a rigid or flexible tube made of metal or insulating material.

2.6 Circuit (or Schematic) Diagram — An explanatory diagram intended to facilitate the understanding of the details of operation. It shows by symbols on an installation or part of an installation, all the electrical connections concerned in its operation.

2.7 Machine Tool — A power driven machine not portable by hand while working which can be used for machining metal, wood, etc, by removal of chips or swarf or by plastic deformation, such as metal cutting, metal forming or wood working.

2.8 Operating Devices — Devices such as push-buttons, selector switches, etc, used for controlling the operation by manual action.

2.9 Power Circuit — Circuit used for supplying power from the mains to apparatus used for the productive operation.

2.10 Raceway — Any channel for holding and protecting electrical insulated or non-insulated conductors and used solely for this purpose.

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*Electrical equipment of machine tools: Part II Electrical equipment of machines used in large series production lines. (*Under preparation*).

†Electrical equipment of machine tools: Part III Electronic equipment of machine tools. (*Under preparation*).

2.11 Servicing Level — Level on which the operator stands when he maintains the electrical equipment.

2.12 Wiring Diagrams — These are intended to guide the execution and checking of the internal and external or both connections of an installation or part of an installation. The drawings may sometime show the layout of the different parts and accessories, such as terminal blocks, and the wiring between them.

3. GENERAL

3.1 Electricity Regulations — Installation of electrical equipment of machine tools shall be carried out in such a manner that it conforms to the relevant portions of the Factories Act and the Indian Electricity Rules.

3.2 Equipment Standards — Electrical apparatus shall comply with the requirements of the appropriate Indian Standards where these exist, otherwise with any internationally accepted standards.

Note — For higher frequency all the electrical equipment shall be suitable for that frequency.

3.3 Radio and TV Interference — When the suppression of interference with radio signals and radio and television broadcasts is required by law, proper measure shall be taken to conform to the regulations.

3.4 Limit switches are not recommended for interlocking.

4. GENERAL REQUIREMENTS

4.1 Supply Voltage — The equipment shall be designed for operation at the supply voltage stated by the purchaser.

Unless otherwise specified by the purchaser the equipment shall operate correctly and in particular, motors shall start and run satisfactorily for a range of voltages between 95 percent and 105 percent of the nominal supply voltage. If there are several supply voltages, the condition shall apply to each of these.

4.2 Connection to Supply Network — The electrical equipment should, as far as possible be connected to a single power supply. If it is necessary to use another voltage or another voltage system for some functions (electronic control, electromagnetic clutches, etc), this other voltage (or system) should, as far as possible, be supplied from apparatus (such as transformers, rectifiers, converters, etc) forming part of the equipment of the machine tool.

4.3 Disconnecting Devices — The electrical control equipment of a machine tool shall be provided with devices enabling:

a) to stop it as fast as possible in case of danger, and
b) to disconnect the whole equipment from the supply voltages.

4.3.1 *Supply Disconnecting Switch*

4.3.1.1 The supply disconnecting device shall be a hand operated device which allows to disconnect the whole electrical equipment of the machine from the power supplies (except the lighting circuit, if necessary), during cleaning of the machine, during maintenance and repairs, and during long service interruptions.

Small machine tools which are supplied by a plug and socket may be disconnected by pulling out the plug.

4.3.1.2 For all other machine tools, the supply disconnecting device shall fulfil the following requirements:

a) Its essential function is to isolate the circuits, it shall have two stable positions only.

b) It shall have a visible gap or a position indicator which cannot indicate ' off ' until there is an adequate gap at all the contacts.

c) It shall be provided with a device permitting it to be locked in the open position, for example, by a padlock.

d) If the machine is connected to one single power supply, the supply disconnecting device shall disconnect all unearthed conductors of the power supply circuit simultaneously, including the neutral (if used).

e) If there is more than one power supply, (*see* **4.2**) separate disconnecting devices may be provided for each supply. Where, there is possibility of danger or damage may be caused by operating one supply disconnecting device only, the circuits shall be arranged with protective interlocks to prevent such danger or damage.

4.3.1.3 If there are lighting circuits which do not pass through the supply disconnecting device, they shall have their own interrupter at the entry of the machine tool. An inscription placed in proximity of the disconnecting device and a corresponding indication in the description shall draw attention to this fact.

If a supply disconnecting device is so placed as to be readily accessible by the operator, its breaking capacity shall be the same as that required for the emergency stopping device.

NOTE — If, by actuating the emergency stopping device according to **4.3.3** the whole equipment is disconnected from the power supply, it may serve also as supply disconnecting device provided that it satisfies all the requirements mentioned in **4.3.1.**

4.3.2 *Additional Isolation Switches* — Machine tool electrical equipment which, in the opinion of the makers, may bring about danger to the operator if it becomes disconnected by the main switch, for example, magnetic chucks, shall be exempted from the requirement of **4.3.1.2**(d) provided that a separate isolating switch is supplied.

4.3.2.1 Local lighting of the machine tool may also be exempted from the requirements of **4.3.1.2** provided that a separate isolating switch is supplied.

4.3.2.2 If the main switch does not disconnect the equipment mentioned in **4.3.2** and **4.3.2.1** it shall be labelled accordingly.

4.3.3 *Emergency Stopping Devices* — The emergency stopping device shall stop the machine as quickly as possible in order to avoid any accident to the operator or the machine tool.

4.3.3.1 For this end, this standard provides two possibilities:

a) An emergency stopping interruptor, operated by hand or electrically inserted in the power supply connections of the machine tool; and

b) A disposition of the control circuits allowing to release simultaneously, initiated by one order only, all switchgear (contactors) of all the critical circuits. If several contactors are connected in series (for example, reversing contactors and star ·delta contactors), the coils of all these contactors have to be released.

The circuits whose interruption could endanger the operator or the machine and other similar apparatus, for example, the excitation of the magnetic chucks, the supply of auxiliary equipment which has to continue functioning in case of disturbance, shall not be interrupted by the emergency stopping device.

The functioning of any braking system fitted to the machine to stop it more rapidly shall not be prevented by actuating the emergency stopping device.

Withdrawal motions may, however, be started by actuating the emergency stopping device, if these motions in no way endanger the personnel.

4.3.3.2 Machine tools provided with more than one operating station or working station shall be provided with at least one push-button for actuating the emergency stopping device at each station.

4.3.3.3 The emergency stopping device shall provide for interrupting the maximum current when the largest motor of the machine is installed together with the sum of the normal running currents of all the other equipment.

If the interrupting means of the emergency stopping device (circuit-breaker, contactor) have a sufficient breaking capacity, they may be provided with releases or relays and serve also as protection against overload and/or short-circuit.

4.3.3.4 The handle or push-button for actuating the emergency stopping device shall be red and located in such a manner as to be readily visible, and easily and quickly reached by the operator from his operating position. If it is a push-button, it shall be of the ' mushroom head ' type, coloured red and preferably with a yellow circle on the surface below the button.

4.4 Protective Measures

4.4.1 *Short-Circuit Protection*

4.4.1.1 *General* — Unless otherwise specified by the purchaser, the manufacturer of the machine tool shall not be responsible for providing short-circuit protection at the point of entry of the main supply cables to the equipment. This protection shall preferably be provided at the origin of the main supply cables.

If the general protective device is provided with means for instantaneous breaking, its setting shall be at least 110 percent of the sum of the peak current of all motors and devices liable to be connected to start, or to operate simultaneously.

4.4.1.2 *Protection of sub-circuits* — Where more than one motor or power circuit are provided, each such circuit within the equipment shall form a separate sub-circuit, each conductor of which shall be protected against short-circuit particularly when the cross section of the sub-circuit's conductor is changed.

Sub-circuits supplying more than one motor may be grouped into a final sub-circuit with a common protection against short-circuits if the maximum rated current of the sub-circuit is not more than 100 A, provided that all the following conditions are complied with:

a) Each motor shall be independently protected by a protective device; and

b) The conductors to the motors shall have a current-carrying capacity equal to that of the conductor feeding the sub-circuit. However, if the length of these conductors to and from the origin of the grouped circuit does not exceed 8 metres, conductors having a current-carrying capacity of at least one-third of that of the conductors feeding the sub-circuit may be used.

NOTE — Where more than one power circuits are grouped as indicated, it is accepted that some thermal overload devices may be damaged in the event of a short-circuit.

4.4.1.3 *Protection by fuses* — Where fuses are provided for short-circuit protection, the ratings of the fuses protecting the circuits shall be selected adequately so as to allow for the overcurrent due to motor starting or switching on of transformers. The maximum rating of the fuses suitable, for the cross section of the conductors of the circuit under consideration shall be determined, according to **6.2.6**.

The fuses should be of a type readily replaceable and shall preferably be of the HRC type. HRC fuses provided shall conform to IS : 2208-1962*.

4.4.1.4 *Protection by circuit-breakers* — Should circuit-breakers be used for the short-circuit protection, they shall be rated and set so as to provide for a protection similar to the one obtained by means of fuses. If the short-circuit current exceeds 90 percent of the breaking capacity of the device for protection of the sub-circuit, the device for general protection of the equipment shall also operate.

4.4.1.5 *Protection by relays* — Protection by instantaneous overcurrent relays in the sub-circuit acting on the common protective device of the grouped circuit or on the emergency stopping device is admissible, if this device has a sufficient breaking capacity.

4.4.2 *No-Voltage Protection* — No-voltage protection shall be provided and arranged so that the machine will not start up again of itself when, following an interruption, the supply is restored.

Such protection shall not necessarily be applied to motors whose automatic restarting after an interruption of supply will cause no risk of injury to the operator or damage to the machine tool or to the work.

If the operation of the machine tool can allow for an interruption of the voltage during a fraction of a second, a delayed no-voltage device may be fitted. (When contactors are used, the delayed interruption and the reclosing shall in no way hinder instantaneous interruption by the control and operating devices, such as limit switches, relays, push-buttons, etc.)

4.4.3 *Protection and Earthing of Control Circuit*

4.4.3.1 *Protection* — In control circuits directly connected to line voltages, fuses or overcurrent tripping devices shall be provided as short-circuit protection, if there is a decrease of cross section of the conductors. However, no such protection is required if the control circuit conductors have a current-carrying capacity of at least one-third of that of the conductors from which they are supplied and the length of lead and return of the control line does not exceed 8 metres.

The same applies to circuit feeding control transformers.

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*Specification for HRC cartridge fuse-links up to 650 V.

In control circuits fed through a transformer of which one end of the secondary winding is connected to earth, short-circuit protection shall be provided in the unearthed conductor of the secondary side. In control circuits fed through a transformer with earthed centre tap of the secondary winding, protection against short-circuit shall be provided in both poles of the secondary side of the control circuit.

4.4.3.2 *Earthing* — Earth faults on any control circuit shall neither cause unintended starting nor prevent stopping of the machine tool.

In order to fulfil this requirement, it is recommended that one side of the control circuit be earthed and the coils and contacts be connected according to **4.4.3.3**.

If in certain cases a centre tap of the control transformer is earthed, it is recommended that an earth leakage protection be used.

NOTE — Some electronic, precision, static and similar control circuits, which require an unearthed isolated circuit, may have no provision for earthing if no danger is caused by lack of such provision.

4.4.3.3 *Connection of coils and contacts* — In control circuit with one side earthed, one end of the operating coils of the control device should be connected directly to the earthed side of the control circuits and all control contacts inserted between the coils and the other side of the control circuit.

Relaxations from this rule are allowed if:

a) Contacts of protective relays (for example, overload relays) may be connected between the earthed side and the coils provided that the conductors between such contacts and the coils of the control device on which the relay contacts operate do not extend beyond a single control enclosure or compartment, and

b) A different arrangement of the contacts leads to a simplification of the external control accessories (trolleys, cable winders, multiple plugs, etc).

With this relaxation very careful design is required to avoid danger in the event of fault.

4.4.4 *Control Circuit*

4.4.4.0 Every endeavour shall be made to arrange the control circuits so as to ensure in all circumstances the safety of personnel, even in the event of faulty operation, and to protect effectively the machine and the work piece, whether there is a failure of the apparatus or a faulty manoeuvre of the operator.

4.4.4.1 *Control circuit supplies* — For machine tools having more than five electromagnet coils (contactors, relays, valves, etc), it is recommended that a transformer should be used for the control circuits. The transformer shall have separate windings and be connected on the load side of the supply disconnecting switch.

4.4.4.2 *Preferred values of control voltages* — Preferred values of control voltages for control circuit connected directly to line or between phase and neutral (for simple equipment) will depend on that of line. For ac control circuits supplied by a transformer, the secondary preferred voltages are 110 and 240 V. For dc control circuits the preferred voltages are 24, 48, 110 and 220 V.

4.4.5 *Protective Interlocks*

4.4.5.1 *Operation of auxiliary functions* — If the non-operating of any motor or any device for an auxiliary function (such as lubrication, suds and swarf removal) may compromise the safety of personnel, cause damage to the machine or impair production, the unintentional stopping of such device shall cause the stopping of all other motors likely to cause an accident if not stopped at the same time.

4.4.5.2 *Interlock between different operations* — Suitable interlocks shall be provided to prevent the functioning of different operations at the same time if these operations might cause damage if working simultaneously.

4.4.5.3 *Interlocking controls for contrary motions* — All contactors and relays controlling elements in opposition linked mechanically or which supervise contrary motions, shall be protected against incorrect operation. Reversing contactors, controlling the direction of rotation of a motor, shall be interlocked in such a way that in normal service no short-circuit can occur when switching.

4.4.5.4 *Reverse current braking* — When reverse current braking is used on a motor, all measures shall be taken to avoid the motor starting in the opposite direction at the end of braking, when this inversion may endanger the personnel or damage the work piece; in such cases the use of a device operating exclusively as a function of time is not allowed.

Furthermore, all measures shall be taken to prevent that any rotation of the shaft of a motor may cause false starting.

4.4.5.5 *Interlocking pick-off gears* — Wherever practicable, doors or covers giving access to compartments containing pick-off gear shall have an interlock switch fixed, where mechanical means of interlock are not fitted, so that the machine tool cannot be accidentally started when the gears are being changed.

4.4.6 *Start of Cycle* — The order for the start of a cycle or operation shall only be possible if all the safety measures for the operators, the machine and the work in progress are fulfilled and if devices for necessary auxiliary functions are working.

Suitable interlocks shall be provided to secure correct sequential starting of cycles and operations. When necessary for set-up purposes, means may be provided to permit individual functioning, but interlocks for the safety of the personnel should still be effective.

4.4.6.1 *Control with both hands* — If a control with both hands is necessary, for the safety of the operators, the equipment shall include two buttons per operator and these buttons shall have to be maintained in working position simultaneously during the whole duration of the cycle, or at least up to the time when the further progress of the cycle does not involve any danger. Each pair of buttons shall be so arranged that their operation requires the continuous action of both hands of the operator.

4.4.6.2 *Non-repetition of the cycle* — On all equipment where the automatic repetition of the cycle is dangerous, the circuits shall be so arranged that this repetition cannot happen, even if action is maintained on any of the controls placed at the disposal of the operator. The machine shall stop at the end of the cycle without the action of the operator.

4.4.6.3 *Stop* — The ' Stop ' functions shall be carried out by the de-energizing of the control devices rather than by the energizing whenever possible. Inversely, the ' start ' functions shall always be produced by excitation.

For emergency stop, *see* **4.3.3.**

4.4.7 *Motor Overload Protection* — Protection of motors against overloading shall be provided for each motor over 1 kW which is normally in continuous operation. As far as economically possible, overload protection is strongly recommended for all other motors.

Single-phase motors shall be protected by at least one overload tripping device. Three-phase motors should be protected by overload tripping devices on each phase, though if agreed by the purchaser, two overload tripping devices only may be provided.

In the case of motors which are called upon to start or to brake frequently, it may be difficult tc provide overload protection with a time constant comparable with that of the winding to be protected. In the case of such motors, it is allowable to provide only short-circuit protection. (Examples of such motors are those used for rapid traverse, locking, rapid reversal, sensitive drilling, etc.) But if the power exceeds 2 kW, it is recommended to use a protection with thermosensitive devices incorporated in the motor.

Where a dangerous situation may arise by self re-starting of any motor after actuation of the tripping device, for example, after cooling of a thermal tripping element, appropriate means shall be provided to prevent such a danger.

Note — An overload protection of conductors on the load side of the supply disconnecting switch is not required.

4.4.8 *Protection Against Electrical Contacts with Live Parts* — Protection shall be provided to prevent contact being made accidentally with live parts at a voltage of more than 50 V. This can be achieved for components contained in enclosures or compartments by one or more of the methods described in (a) to (d) below.

When it is expressly specified that other than authorized persons may have access to electrical apparatus which it is not possible to operate from the outside (replacement of fuses, for example), one of the methods of protection as stated in (a) and (b) shall be used.

a) By covering all live parts with insulating material so that there is no possibility of touching them accidentally even when the door is open.

b) By interlocking the door or doors with the isolating switch so that they can only be opened when the isolating switch is open, and so that the isolating switch cannot be closed when the door or doors is/are open. It is recommended that such a device shall, however, permit authorized persons to obtain access when the equipment is live (provided that on re-closing the door, the interlock is automatically restored).

c) By fastening doors or covers to enclosures or compartments with fasteners which require the use of a tool for their removal.

d) By closing the doors or covers to cabinets or compartments with a lock which requires a detachable key for opening.

Note — When adjustments or re-settings are required, an authorized person should be called.

4.5 Control Enclosures and Compartments

4.5.1 *Mounting of the Apparatus*

4.5.1.1 *Mounting in control enclosures and compartments* — Control enclosures and compartments shall secure an adequate protection against effects of the surroundings in which the machine is intended to operate, for example, against dust, against the ingress of oil, coolants or chips, and against mechanical damage. Units which are particularly sensitive should be given additional protection.

The degree of protection should be chosen from those defined in IS : 2147-1962*.

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*Degrees of protection provided by enclosures for low-voltage switchgear and controlgear.

Heat generating components (resistors, valves, etc) should be so located that the temperature-rise of components inside the control enclosure or compartment is kept within permissible limits.

4.5.1.2 *Concentration of control apparatus* — As far as practicable, control and switching apparatus on the machine tool other than push-buttons, limit switches or operator controlled switches should be grouped and mounted in one enclosure or compartment.

4.5.1.3 *Accessibility* — Electrical apparatus mounted in enclosures or compartments shall be installed so that access to it is readily obtained when the door is open or when covers or hoods have been removed, and without requiring the dismantling of other parts of the machine tool.

All electrical apparatus shall be installed so that it can be easily checked for correct operation and, if necessary, parts or assemblies can be easily replaced.

All connection terminals shall be easily accessible.

Various forms of protection against accidental contact with live parts are described in **4.4.8**.

NOTE — If authorized persons need access to incoming terminals or apparatus remaining alive after opening doors interlocked with isolating switches as described in **4.4.8** (b), it may be necessary to remove supplementary safeguards.

4.5.1.4 *Height of installation* — Apparatus requiring easy access for maintenance and adjustment shall not be situated below 400 mm and above 2 000 mm from the servicing level.

The connection terminals of all apparatus and the interconnection terminals shall be situated at least 200 mm from the floor or servicing level. Terminals should be so placed that the cables may be easily connected to them.

4.5.2 *Requirements for Control Enclosures and Compartments*

4.5.2.1 *Construction and arrangement* — Control enclosure and compartment shall be so enclosed as to give the adequate protection specified in **4.5.1.1**. They should not be considered to be enclosed if open to the floor, or the foundation on which the machine tool rests, or to other parts of the machine tool.

There shall be no opening between compartments containing electrical apparatus and reservoirs holding coolant, lubricating or hydraulic oils or to other compartments into which oil or other liquids could penetrate.

NOTE — These requirements do not apply to electrical apparatus intended to operate in oil, as for example, electromagnetic couplings.

A suitable opening may, however, be provided in the case of larger compartments so that moisture due to condensation may drain away.

4.5.2.2 *Fixing of the enclosures* — If there are holes in a control enclosure for the purpose of mounting it on the machine tool, care should be taken that they do not impair the protection assured by the enclosures and compartments.

4.5.2.3 *Ventilation* — If the arrangement recommended in **4.5.1.1** for heat generating apparatus fails to prevent increase in temperature which would have deleterious effects, ventilation may be provided.

It is recommended that the available space be divided into a ventilated section containing the heat generating components and a protected section containing the other components.

The ventilation system shall be designed so as to prevent, as far as possible, the ingress of dust and liquid into the enclosures and compartments.

4.5.2.4 *Doors* — Enclosures and compartments containing electrical apparatus shall be provided, as far as possible, with doors having vertical hinges.

If doors are closed by means of screws and bolts, these shall be of the captive types.

Doors should preferably be not wider than 900 mm.

4.5.2.5 *Dimensions of mounting panels or plates* — The dimensions of mounting panels or plates of the equipment shall provide for their free passing through the enclosure openings.

Space should be left where appropriate for modifications or minor additions to the control equipment.

4.5.2.6 *Mechanical parts* — Mechanical parts to which access is necessary during the normal operation of the machine tool and moving parts (rotating shafts) shall under no circumstances be contained in control enclosures and compartments.

Any means of making mechanical adjustments which is not associated with electrical equipment shall be so placed that it is not in the same enclosure or compartment with electrical equipment.

Electrical control equipment shall be so mounted that it does not interfere with any mechanical machine-tool adjustment or with the maintenance of mechanical or hydraulic equipment.

4.5.3 *Handling of Control Enclosures* — Heavy and bulky control enclosures which have to be removed from the machine tool for transport or which are independent of the machine tool shall be provided with hooks or shackles suitable for their handling by means of cranes.

4.6 Control and Operating Devices

4.6.1 *Control Devices*

4.6.1.1 *Mounting* — Control devices shall be readily accessible for ease of replacement and installed, as far as possible, in dry and clean location.

4.6.1.2 *Protection of control devices* — All control devices external to those wholly contained within control enclosures or compartments, such as limit switches, magnetically-operated valves, pressure operated switches, etc, shall be protected against any effects due to the environment in which the machine tool will operate and against mechanical damage. This protection may be achieved by one or several of the following methods:

a) By providing suitable location for the control devices;

b By using materials and construction having suitable strength to withstand any mechanical stress that may occur; and

c) By using covers and other devices giving an adequate protection against the entry of chips, dirt, dust, oil and coolants.

The degree of protection should be chosen from those defined in IS : 2147-1962*.

4.6.1.3 *Limit switches or position sensors* — Limit switches or position sensors shall be so arranged that they will not be damaged in the event of accidental overtravel. Limit switches used for safety purposes shall have a safe linkage between the member which is mechanically actuated and the contacts. For example, if a spring in the mechanism should break, the switch shall still operate in such a way as to prevent danger.

4.6.2 *Operating Devices*

4.6.2.1 *Accessibility* — The operating devices shall be mounted within easy reach of the machine-tool operator in his normal working position. They shall be so placed that in order to reach them the operator need not come within a dangerous distance of the spindles or other moving parts.

The starting devices should be designed and arranged so as to avoid the danger of unintentional operation.

4.6.2.2 *Protection* — Precaution should be taken against dust, and where appropriate, against oil or coolant spray or drip interfering with the operation or shortening the life of the insulation.

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*Degrees of protection provided by enclosures for low-voltage switchgear and controlgear.

The degree of protection shall be at least IP 53, or where appropriate IP 55 as defined in IS : 2147-1962*.

4.6.2.3 *Push-buttons* — The push-buttons used, their relative position and colour shall be in conformity with IS : 6875 (Part II)†. In addition, the following shall apply.

a) *Colour of push-buttons* — The colour RED shall be used for the function ' Stop ' only; all buttons or handles for ' Emergency stop ' and the ' Stop ' buttons (if the same button is not used for ' Start ' also) shall always be RED.

The recommended application of the other colours for push-buttons used on machine tools are indicated in Table 1. (The above mentioned requirements for RED are also included).

b) *Marking of push-buttons* — In addition to the marking according to **10.1.2**, the stop and start push-button shall be marked with the words ' O ' and ' I ' respectively, near or directly on the push-button, as an indication for persons who have difficulties in distinguishing red from green.

c) *Mushroom-head push-buttons* — Mushroom-head push-buttons are reserved for the emergency stop, both in automatic and in manual operation.

However, they may be used as ' start of cycle ' buttons for operation ' with both hands ' or for machines equipped with mechanical guards. In these cases, the buttons shall not be red.

4.6.2.4 *Signalling lamps* — The recommended colours of the signalling lamps used on machine tools are indicated in Table 2.

4.6.2.5 *Illuminated push-buttons* — Illuminated push-buttons which show only one and the same colour when illuminated and when dark, and return to their rest position by themselves, when they are released, are considered in the following text:

a) *Indication* — A button is lighted to give the operator an indication that he may or should press the lighted button, or in some instances, to perform a certain task and then press the button.

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*Degrees of protection provided by enclosures for low-voltage switchgear and controlgear.

†Specification for control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages up to and including 1 000 V: Part II Push-buttons and related control switches.

TABLE 1 COLOUR AND FUNCTIONS OF PUSH-BUTTONS

[*Clause* 4.6.2.3(a)]

COLOUR	FUNCTION	EXAMPLE OF APPLICATION
(1)	(2)	(3)
Red	a) Stop	i) Stop of one or several motors ii) Stop of machine elements iii) De-energizing of magnetic chucks iv) Stop of the cycle (if the operator pushes the button during a cycle, the machine stops after the relevant cycle is completed)
	b) Emergency stop	General stop
Yellow	Start of a return motion not in the usual operating sequence	Return of machine elements to the starting point of the cycle, if the cycle has not been completed
	Start of an operation intended to avoid dangerous conditions	Pressing the yellow push-button may override other functions which have been selected previously
Green	Start (preparation)	i) Energizing of the control circuits ii) Start of one or several motors for auxiliary functions iii) Start of machine elements iv) Energizing of magnetic chucks
Green or Black	Start (execution)	i) Start of a cycle or a partial sequence ii) Inching, jogging
White or Light Blue	Any function not covered by the above colours	i) Control of auxiliary functions which are not directly related to the working cycle ii) Reset of protective relays (if the same button is used for 'Stop', it shall be RED).

NOTE — It is recommended not to use other colours, as for example, orange, grey or brown, in order to have a clear distinction between the different colours.

When the order, given by pressing the button, has been executed, the light extinguishes.

Only the colours RED, YELLOW, GREEN and BLUE shall be used in this mode.

NOTE — For illuminated RED or YELLOW push-buttons used in the mode of 'indication', a flashing light may be used in order to attract the attention of the operator, as in the case of an alarm. When used in such a way, the pressing of the button may change the flashing light into a steady light. In addition, the button may have the same function as according to **4.6.2.3**, but no others. The steady light then remains on, until the cause of the alarm (such as low oil level) has been eliminated by separate action.

b) *Confirmation* — When a dark button has been pressed, its lamp lights up as a confirmation that the order, given by pressing the button, has been executed. It remains lighted, until a contrary order follows.

Only the colour WHITE (or clear) shall be used in this mode.

NOTE — White illuminated push-buttons may be used with a flashing light in order to give a double confirmation. When the button is pressed, the light starts to flash to confirm that a starting operation or sequence has been initiated. When this has been completed, the light automatically changes to steady to confirm that normal running conditions have been established.

Recommendations for the application of colours for different significations and functions of illuminated push-buttons are shown in Table 3.

5. ELECTRIC MOTORS

5.1 General Requirements

5.1.1 *Compliance with Indian Standards* — All motors shall comply with the provisions of the appropriate Indian Standard for performance (*see* IS : 325-1970* and IS : 996-1964†).

5.1.1.1 *Power factor correction* — Where the purchaser requires that power factor correction capacitors to be supplied, it should be noted that kVA rating of the capacitor should not exceed 85 percent of the magnetizing current of the motor to which it is connected. If this requirement is not observed, the equipment may be seriously damaged by voltages set up by the self-excitation of the motor (*see also* IS : 900-1965‡).

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*Specification for three-phase induction motors (*third revision*).

†Specification for single-phase small ac and universal electric motors (*revised*).

‡Code of practice for installation and maintenace of induction motors (*revised*).

TABLE 2 COLOUR AND SIGNIFICATION OF SIGNALLING LAMPS

(*Clause* 4.6.2.4)

COLOUR (1)	SIGNIFICATION (2)	EXAMPLE OF APPLICATION (3)
Red	Abnormal conditions requiring immediate action by the operator (*see* Notes 1 and 2)	Order to stop the machine immediately (for example, because of an overload) *or* To indicate that a protective device has stopped the machine (for example, because of an overload, overtravel or another failure)
Yellow (Amber)	Attention or caution (*see* Note 1)	Some value (current, temperature) is approaching its permissible limit *or* Automatic cycle running
Green	Machine ready	Machine ready for operation: all necessary auxiliaries functioning, units in starting position and hydraulic pressure of output voltage of a motor-generator in the specified range, etc Cycle completed and machine ready to be restarted
White (Clear)	Circuit energized normal conditions	Main switch in 'ON' position (*see* Note 2) Choice of the speed or the direction of rotation Auxiliaries not related to the working cycle are functioning
Blue	Any signification not covered by the above colours	i) Selector switch in 'Set up' position ii) A unit in forward position iii) Microfeed of a carriage or unit

NOTE 1 — For the significations 'Abnormal conditions requiring immediate action' or 'Attention', a flashing signal of the appropriate colour may be used, accompanied by an audible signal, if desired.

NOTE 2 — For 'Main switch in ON position', RED may be used if the signalling lamp is not on the operator control station.

TABLE 3 COLOUR AND FUNCTIONS OF ILLUMINATED PUSH-BUTTONS

(*Clause* 4.6.2.5)

COLOUR AND MODE OF USE (1)	SIGNIFICATION OF THE LIGHTED BUTTON (2)	FUNCTION OF THE BUTTON (3)	EXAMPLES OF APPLICATION AND REMARKS (4)
Red, Indication	*See* Note 1	Stop (*see* Note 2) and in some instances reset (only if this same button is also used for ' Stop ')	—
Yellow (Amber), Indication	Attention or caution	Start of an operation intended to avoid dangerous conditions	Some value (current, temperature) is approaching its permissible limit Pressing the yellow push-button may override other functions, which have been selected previously
Green, Indication	Machine of unit ready for operation	Start after authorization by the lighted button	i) Start of one or several motors for auxiliary functions ii) Start of machine element iii) Energizing of magnetic chucks or plates iv) Start of a cycle or a partial sequence (*see also* Note 3)
Blue, Indication	Any signification not covered by the above colours and by white	Any function not covered by the above colours and by white	Indication or order to the operator to perform a certain task in the normal sequence, for example, to make an adjustment (after having fulfilled his duty, he presses the button as an acknowledgement)

(*Continued*)

TABLE 3 COLOUR AND FUNCTIONS OF ILLUMINATED PUSH-BUTTONS — *Contd*

COLOUR AND MODE OF USE (1)	SIGNIFICATION OF THE LIGHTED BUTTON (2)	FUNCTION OF THE BUTTON (3)	EXAMPLES OF APPLICATION AND REMARKS (4)
White (Clear), Confirmation	Permanent confirmation that a circuit has been energized	Closing of a circuit *or* Start *or*	i) Energizing of an auxiliary circuit not related to the working cycle
	or that a function or a movement has been started or preselected	Preselection	ii) Start or preselection of direction of feed motion of speeds, etc

NOTE 1 — The use of RED illuminated push-buttons is not recommended, but, if used, its signification shall be strictly in accordance with **4.6.2.4**.

NOTE 2 — Emergency stop buttons are never illuminated push-buttons.

NOTE 3 — For inching and jogging non-illuminated black (or green) push-buttons should be used.

NOTE 4 — The signification of the colours shall be strictly in accordance with the table or for cases which are not covered by the table with **4.6.2.3** and **4.6.2.4**. Where this is not possible with illuminated push-buttons, separate push-buttons and lamps shall be used.

5.1.2 *Standard Dimensions* — The motors shall comply with the requirements of the relevant Indian Standards (*see* IS : 996-1964*), IS : 1231-1967† and IS : 2223-1971‡.

5.1.3 *Choice of Motors* — The characteristics of the motors shall be determined in accordance with the service conditions under which they shall operate. In this respect, distinction is made between the following three classes of motors:

a) Continuously operating motors;

b) Motors for frequent starting and reverse-current braking; and

c) Motors for driving machine tool with large inertia which shall have a suitable slip (for example, motors for presses).

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*Specification for single-phase small ac and universal electric motors (*revised*).

†Dimensions of three-phase foot-mounted induction motors (*second revision*).

‡Dimensions of flange mounted ac induction motors (*first revision*).

The manufacturer should pay particular attention to the following points:

a) Motor torque at standstill and minimum torque during starting period compared with the resistive torque of the machine,
b) Required maximum torque,
c) Normal torque in continuous operation,
d) Possibility of overload,
e) Frequency of starting and braking, and
f) Variation of load with time.

5.2 Type of Protection — Preferably totally enclosed motors with or without fan cooled frame be used.

Motors incorporated as an integral part of the machine tool shall be so mounted that they are adequately protected mechanically and that their temperature-rise remains within the limits specified in IS : 325-1970* and IS : 996-1964†.

5.3 Mounting of Motors

5.3.1 *Accessibility* — Each motor shall be mounted so as to be easily accessible for inspection, maintenance, lubrication and shall allow for disconnection of the conductors and for demounting of the motor. It shall be easily possible to tension or replace belts or chains and to align couplings.

In particular, its fixing bolts, terminals, slip-rings, bushes and lubrication points shall be easily accessible.

It should not be exposed to the risk of damage during replacement.

Motor compartment shall be clean and dry and provided with vents communicating directly with the outside of the machine. These vents shall be sufficiently high above the floor or the servicing level so that when the latter is swept or cleaned, no dust, swarf or water spray can penetrate inside the compartment.

There shall be no aperture between the motor compartment and any other compartment which does not comply with the above requirements.

5.3.2 *Lubrication* — Unless sealed-for-life or similar bearings are incorporated, readily accessible lubricating points shall be provided.

5.3.3 *Ventilation* — If motor is mounted inside the machine tool, it is essential that the cooling air to the motor is not restricted and the motor shall be sufficiently ventilated to keep the cooling air temperature inside

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*Specification for three-phase induction motors (*third revision*).

†Specification for single-phase small ac and universal electric motors (*revised*).

the compartment within corresponding limits specified in the relevant Indian Standards, where these exist.

5.3.4 *Alignment and Dowelling* — All direct-coupled foot-mounted motors shall be properly aligned and dowelled in position.

5.3.4.1 Flange mounted motors shall be dowelled, unless otherwise positively held in alignment.

5.4 Balance — The extent to which static and dynamic balancing of motors is carried out shall be limited to the elimination of machining troubles from these sources.

5.4.1 Precision balanced motors shall be so indicated on the motor name-plate and in the list of units in the equipment.

5.5 Starting — The method of starting ac squirrel cage motors shall be agreed with the purchaser of the machine tool, subject to the conditions given below:

a) Three-phase motors may be started directly across the line up to limits of power which depend on several factors, such as:
   1) the characteristics of the network at the point of supply to the machine tool,
   2) the size of the transformers supplying this network,
   3) the regulation of the supply authority, and
   4) the ratio of starting to running current in the motors employed;

b) The purchaser of the machine tool is advised to furnish to the supplier the information contained in Appendix A and particularly with any relevant limits on power and the starting current permissible at the point of supply to the machine tool; and

c) In the absence of such information the supplier shall assume that motors up to 10 kW may be started directly across the line.

5.6 Name-Plates — When a motor is built into the machine tool or if the name-plate of a motor is not clearly visible when the motor has been placed into its compartment, a second name-plate shall be placed in a clearly visible position in the neighbourhood of the motor. A plate showing the direction of rotation of the motor shall be fixed to the machine, when the reversal of the direction may be dangerous for the operator or damage the machine.

6. WIRING

6.1 General

6.1.1 *Regulations for Cables* — The current-carrying capacity of cable shall be in accordance with relevant Indian Standards.

6.1.1.1 *Connections* — All connections, including those of earth continuity conductors, shall be secured against accidental loosening.

6.1.1.2 *Cable runs* — All cables shall be run continuously from terminal to terminal without intervening joints.

Branch connections shall be permitted only in easily accessible, but covered, and strongly constructed junction or terminal boxes.

6.1.1.3 *Conductors of different circuits* — Conductors of different circuits may be laid side by side, or may occupy the same raceway or may be contained in the same cable. If they are operated at different voltages, they shall either be separated by suitable barriers, or all be insulated for the highest voltage to which any conductor within the same cover may be subjected.

6.1.1.4 *Cable lugs* — As far as possible soldered lugs shall be avoided.

6.1.1.5 *Terminals and terminal boxes* — All terminals shall be placed in easily accessible and strongly constructed enclosures or compartments providing protection against accidental contact and against mechanical damage.

The terminal used shall be of such construction that shall not damage the ends of connected conductors. They shall be secured against accidental loosening due to vibration.

6.1.1.6 *Identification of wiring* — The colours used for cables shall be in accordance with IS : 375-1963*.

6.1.2 *Laying of Cables Inside Control Enclosures and Compartments*

6.1.2.1 *Internal raceways* — Raceways used inside enclosures of compartments should permit the laying of additional cables at a later date if required.

Cables which are not run in raceways shall be adequately supported.

6.1.2.2 *Interconnection terminals* — Interconnection terminals shall be provided for all circuit cables entering control enclosures or compartments and such terminals shall be marked in accordance with the diagrams.

Where main supply or power cables enter a control enclosure or compartment the corresponding terminals shall be easily accessible and suitably grouped.

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*Marking and arrangement for switchgear bus-bars, main connections and auxiliary wiring (*revised*).

The terminals of the supply disconnecting switch or of any electrical apparatus may be used for the connection of external supply or power cables.

For apparatus mounted on a door, terminal strips shall be provided fixed on the enclosure or on the door. The connections shall be made with flexible conductors allowing for frequent and easy opening of the door without risk of damage. The conductors are anchored to the door on the one hand and to the enclosure on the other, independently of the fixing of the ends on the terminals.

6.1.3 *Laying of Cables Outside Control Enclosures and Compartments*

6.1.3.1 *External raceways* — All wiring, other than that of suitably protected cables, outside control enclosures and compartments shall be laid in conduits or raceways resistant to heavy mechanical stresses and providing protection against the penetration of liquids, chips and dust. The conduit used shall conform to IS : 1653-1972*.

Cables may be laid in raceways within the frame of the machine tool without further precautions, provided that the protection against entry of liquid, chips and dust corresponds to degree IP 53 of IS : 2147-1962†.

All sharp edges, rough surfaces or sharp threads with which the insulation of the cables may come into contact shall be smoothed off to prevent damage to the insulation.

Raceways shall be secured and so arranged that they will not be subject to mechanical damage or abrasion.

It is recommended that the dimensions of the conduits and raceways should permit the easy laying of additional cables, other than power cables, at a later date if required.

6.1.3.2 *Connection to moving elements* — Flexible cables shall be used for the connections to moving or adjustable elements in which electrical equipment is incorporated.

Flexible metallic conduits shall only be used for slow and infrequent movements. The flexible conduit, if used, shall conform to IS : 3480-1966‡. If required, the flexible conduits shall provide for an adequate protection against the entry of oil, coolant or dust, for example, by turning the ends downwards.

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*Specification for rigid steel conduits for electrical wiring (*second revision*).

†Degrees of protection provided by enclosures for low-voltage switchgear and controlgear.

‡Specification for flexible steel conduits for electrical wiring.

The ends of the conduits shall make good electrical contact with the earthed machine-tool parts.

The cable sheath shall resist without injury the effects which may be expected by mechanical movements and by the action of oil, coolants, chips and temperature.

The hanging loop shall have a sufficient length to provide for a bending radius of the cable of at least 10 times its outer diameter.

Where cables subject to movement are close to moving parts, precautions shall be taken so that a space of at least 25 mm shall at all times be maintained between the moving parts and the cables. If it is not practicable to keep the minimum distance, fixed barriers should be provided between the cables and the moving parts.

Cables subject to movement shall be supported in such a way that there is no mechanical strain on the connection points, nor any sharp flexing.

In case of pendant enclosures, the weight of the enclosures shall be supported by means other than the electrical cable.

6.1.3.3 *Test points* — It is recommended that on complex machine tools, when several switching devices (such as limit switches, push-buttons, etc) are connected in series and/or parallel, the conductors between them shall be returned to terminals forming intermediate test points conveniently placed and adequately protected. These test points shall be shown on the relevant diagrams.

6.1.3.4 *Plug and socket connections* — The plug and socket shall be designed so that an earth continuity connection shall be made before any live connections are made and not disconnected until all the current-carrying conductors of the plug circuit are dead.

The plug and socket shall be of a type which will prevent inadvertent contact with live parts at any time, even during insertion or withdrawal of the plug.

The socket shall be mounted on the side from which the power is supplied.

Plug and sockets shall be of locking type to prevent accidental disconnection. The sockets shall be provided with a cover to prevent the entrance of oil, chips or dust whenever the plug is removed.

6.1.3.5 *Dismantling for shipment* — When parts of a machine tool are designed for dismantling for shipment, appropriate terminals shall be provided for all electrical cables subject to such dismantling. These terminals shall be suitably enclosed and the cables shall be identified with the same marking as the associated terminals.

6.2 Types of Wires and Cables

6.2.1 *Grade of Cables* — When the voltage to earth exceeds 250 volts, the cable shall be of 650/1 100 volt grade, that is, medium voltage heavy-duty type, but when the voltage to earth does not exceed 250 volts, either 250/440 volt grade or 650 volt grade cable may be used (*see* IS : 434-1964* and IS : 694-1964†).

6.2.2 *Cables Exposed to Oil and Coolant* — Where the cables are subjected to exposure to oil and coolant, thermoplastic, thermosetting, or suitable inorganic insulation or sheathing materials, or both, shall be used.

6.2.3 *Cables Subjected to High Temperature and/or High Humidity* — The cables selected shall be suitable for the temperature and humidity conditions likely to be obtained in practice.

6.2.4 *Cables Subjected to Movement* — All cables which are subjected to movement shall have flexible stranding together with sufficient allowance in length to avoid all sharp flexing and strain.

6.2.5 *External Cables* — For fixed wiring stranded conductors shall be used.

Mineral insulated metal-sheathed cables with solid conductors may be used between rigidly mounted non-moving parts.

The use of bare conductors is permitted on the load side of the supply disconnecting switch provided that their diameter be at least 3 mm (round conductors) or that their thickness be at least 2 mm (flat conductors). They shall be rigidly mounted between non-moving parts and adequately protected against accidental contact.

6.2.6 *Cross Section of Conductors and Corresponding Rating of Short-Circuit Protective Devices* — The cross section of conductors of cables used for the wiring of a distinct circuit shall be at least equal to any one of the cross sections determined according to **6.2.6.1** to **6.2.6.4**.

6.2.6.1 *Current-carrying capacity* — Depending on the highest possible steady current under normal working conditions in the circuit considered, the corresponding cross section shall be determined according to Appendix B (*under consideration*).

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*Specification for rubber-insulated cables:

Part I With copper conductors (*revised*).

Part II With aluminium conductors (*revised*).

†Specification for PVC insulated cables (for voltages up to 1 100 V):

Part I With copper conductors (*revised*).

Part II With aluminium conductors (*revised*).

Note — Special recommendations for intermittent duty are under consideration.

6.2.6.2 *Voltage drop* — In order to avoid excessive voltage drop during the pulling-in of ac magnet coils or the starting period of motors or other current peaks it might be necessary to use larger cross sections than determined by **6.2.6.1**, especially in case of long connections. In such cases the impedance of the cables, the peak current, the voltage drop at the point of supply and the permissible voltage drop at the terminals of current consuming apparatus should be considered.

6.2.6.3 *Rating of short-circuit protective devices* — The nominal current of fuses or the current setting of the other protective devices (*see* **4.4.1.2**), shall not be higher than ....* percent of the permissible current according to Appendix B (*under consideration*).

If, in order to take care of current peaks or for other reasons, protective devices with a higher nominal current (in the case of fuses) or a higher current setting (in the case of other protective devices) have to be used, the cross section shall be increased accordingly.

Exceptions are allowed for grouped circuits according to **4.4.1.2** (b) and control circuits according to **4.4.3.1**, where the nominal current or the current setting of the protective device may be up to three times the permissible current of the conductor. In addition to the cases where the total length of line does not exceed 8 metres (as mentioned in **4.4.1.2** and **4.4.3.1**) the same deviation is allowed for the wiring inside control enclosures only, if the length of line inside does not exceed 8 metres, under the condition that all other requirements in the relevant clause are fulfilled and the terminals for the outside wiring are dimensioned for the full cross section.

6.2.6.4 *Minimum cross sections of copper conductors* — For mechanical reasons the cross sections used shall be not less than:

a) For conductors outside control enclosures and compartments:

1·0 mm^2 for stranded conductors.

If (as an exception) solid conductors are used, they shall have a minimum cross section of 1·5 mm^2.

b) For multicore cables outside control enclosures and compartments:

0·75 mm^2 for 2 and more cores.

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*Value under consideration.

For the connection of very low-current circuits, such as electronic logic and similar low-level (signal) circuits:

0·5 mm^2 for cables with 2 and more cores,

0·3 mm^2 for cables with 3 and more cores, and

0·3 mm^2 for screened 2-core cables.

The terminations of such cables shall be fixed in such a manner as to prevent strain on the ends of the conductors.

Flexible cables and connecting parts of machine tools, subject to frequent movement, shall have a minimum cross section of 1·0 mm^2.

c) For conductors inside control enclosures and compartments:

0·75 mm^2.

For the connection of very low-current circuits, such as electronic logic and similar low-level (signal) circuits:

0·2 mm^2.

d) Conductors with smaller cross section may only be used where necessary for the proper functioning of the equipment.

In all cases, the connecting devices shall be suitable for the cross section and the nature of the conductors to be connected to them.

NOTE — For certain types of terminals, which are not proper for the connection of small stranded conductors, tubular ferrules pushed over the ends of the conductors may enable to make safe connections.

7. EARTHING

7.1 Earthing of Metal Parts — Separate control enclosures as well as the machine tool itself shall be provided with earthing terminals.

All metal parts of the machine tool and accessories in which electrical equipment is contained, whether an integral part of the machine tool itself or whether moving or independently mounted, shall be connected together electrically so that the entire machine tool can be connected to earth.

Provided that all paint and grease are removed from the jointing surfaces, bolts or screws which are used to secure parts of machine tools together shall be considered as providing earth continuity.

If multiple conductor cables are used for connection to moving parts or pendant stations, an earth continuity conductor shall be provided in the cable.

7.1.1 The resistance between the earthing terminal and any metal part of the machine tool which may become live due to insulation fault shall not exceed 0·1 ohm.

7.1.2 The following conditions shall be observed while earthing:

a) Flexible metallic conduit shall not be used as an earth continuity conductor.

b) The exposed metal of each item of removable or separately mounted equipment shall be suitably connected to the earthing terminal provided on the machine tool.

c) Bolts or screws which are used to secure parts of machine tool together shall be considered as providing earth continuity provided that all paint and dirt are removed from the jointing surfaces.

NOTE — For the purpose mentioned in (c), the driving motor or motors, including pivoted mounted motors, shall be taken as part of the machine tool provided that bolts or screws are used to attach the motor support to the machine tool.

d) Covers to which control apparatus is fixed, whether hinged or similarly supported, and which comply with **4.5.2**, shall be considered as connected electrically to the machine tool.

e) Small isolated metal parts, such as knobs, ferrules and the like, which are not liable to come into contact with any electrical equipment during the operation of the machine tool, need not be earthed.

f) The neutral conductor shall not be used for earthing purposes.

NOTE — Moving parts of a machine tool other than removable accessories or attachments, which have substantial metal-to-metal bearing surfaces shall be considered as connected together electrically through such bearing surfaces for purposes of earthing, except where direct electrical connections are made to the moving parts.

g) Screws and terminals for the connection of earth continuity conductors shall not have any additional function of mechanical fastening.

h) Moving parts, other than removable accessories or attachments which have slide-way type metal-to-metal bearing surfaces, shall be considered as connected together electrically through such bearing surfaces for purposes of earthing.

7.2 Portable and Pendant Equipment

7.2.1 *General* — The exposed metal of all portable accessories or pendant stations shall be suitably connected to the earthing terminal on the machine tool.

7.2.2 *Earth Continuity* — An earth continuity conductor for all the portable and pendant equipment of a machine tool shall be included as one of the conductors of that machine tool.

7.2.3 *Colour* — The earth continuity conductor shall be coloured green which colour shall be reserved for this purpose (*see* IS : 375-1963*).

7.3 Main Earthing Terminal — A main earthing terminal shall be provided close to the main input terminals. It shall be of such a size as to enable the connection of an earth continuity conductor of the following cross section:

Cross Section of the Main Conductors Supplying the Equipment	*Cross Section for which the Main Earthing Terminal has to be Dimensioned*
Up to and including 16 mm²	Equal to that of the main conductors
Larger than 16 mm²	At least 50 percent that of the main conductors with a minimum of 16 mm²

7.3.1 *Cross Section of Internal Earth Continuity Conductors* — Earth continuity conductors within the equipment and the machine tool shall have at least the following cross section:

Nominal Current of the Fuses or Circuit-Breaker Protecting the Associated Circuit	*Cross-Sectional Area of the Earthing Conductor*
A	mm²
Less than 200	The same as the conductors of the associated circuit but not more than 16 mm²
200	16
315	25
500	35
800	50
1 000	70
1 250	95
1 600	120
2 500	185
3 200	240

---

*Marking and arrangement for switchgear bus-bars, main connections and auxiliary wiring (*revised*).

If an earthing conductor other than copper is used, its electrical resistance per unit of length shall not exceed that of the allowable copper conductor.

7.4 Earth Leakage Tripping — In special cases and when requested by the purchaser of the machine tool, the direct earthing may be complemented by an earth leakage circuit-breaker, or be replaced by an earthing relay acting on a circuit-breaker or on a warning lamp.

8. ELECTRICAL ACCESSORIES

8.1 Connections to Accessories — When a machine tool is provided with an outlet for the connection to accessories, it may be connected directly to the mains conductors or to the secondary of a transformer, and shall be provided with an earthing connection.

When the voltage is obtained from a transformer, a power of at least 100 VA shall be available for the accessories.

The unearthed wires shall be protected against short-circuits by fuses of circuit-breakers and such protection shall be independent of the protection of the control circuits even where both are derived from a common source of supply.

9. LOCAL LIGHTING OF THE MACHINE

9.1 Supply — The circuits for the machine lighting shall preferably be supplied by means of a transformer.

Lamps which are fixed in position or are built-in may be supplied directly at mains voltage. Lamps should not be connected to voltages higher than 250 V.

Supply cables for movable lamps with voltages exceeding 50 V shall be provided with an earth continuity conductor.

For disconnecting switch, *see* **4.3**.

9.2 Transformer — The transformer, when used, shall be double wound and the secondary side of the transformer shall be earthed preferably at the mid-point.

9.2.1 Overcurrent protection shall be provided in both the primary and secondary circuits of the transformer. If the secondary is either floating or earthed at the mid-point, fuses shall be provided on both poles of the secondary.

9.3 Protection of the Lighting Circuits — All unearthed wires of the lighting circuits shall be protected against short-circuits by fuses or circuit-breakers separate from those supplying other circuits.

9.4 Lighting Fittings — Adjustable lighting fittings shall be suitable for workshop use.

9.4.1 The lampholders shall be made of insulating material protecting the lamp cap so as to prevent contacts being made accidentally. They shall comply with the relevant Indian Standards.

9.4.2 The switch shall not be incorporated in the lampholder or on the connecting cords if the supply voltage exceeds 50 V.

9.4.3 Reflectors shall be supported by the bracket and not by the lampholder.

9.4.4 If the lighting fittings of the lamps are metallic, they shall be connected to earth.

9.5 Fluorescent Lamps — When fluorescent lamps are used, precautions shall be taken to prevent stroboscopic effect on moving parts annoying the operator and accessories shall comply with the relevant Indian Standards.

10. MARKING AND OPERATING INSTRUCTIONS

10.0 Marking — All enclosures and all compartments which do not clearly show that they contain electrical apparatus shall be marked with a lightning flash in red colour as shown in Fig. 1.

10.1 General Marking — All electrical equipment shall be legibly and indelibly marked in such a way as to be readily visible when the equipment is installed.

Whenever possible, there shall be at least one name-plate with the following details:

a) Name of the manufacturer of the electrical equipment, or his trade-mark;

b) Nominal voltages with indication of dc or ac and the frequencies if ac (for each supply if more than one);

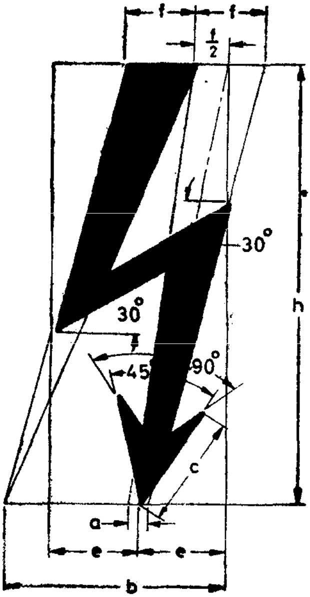
c) Rated currents; and

d) Serial number or other identification of the equipment.

Where the control equipment is housed in a control compartment, the marking may be included on the machine-tool name-plate.

10.1.1 *Motor Name-Plates* — When a motor is in position on a machine tool, the motor name-plate shall be readily visible in upright position.

Name-plates shall be left in position on motors and shall not be removed or painted over (*see also* **5.6**).



Nominal Size *h*	*a*	*b*	*c*	*e*	*f*
16	0·6	8	4	3·2	2·5
20	0·8	10	5	4	3·2
25	1·0	12·5	6·3	5	4
32	1·2	16	8	6·3	5
40	1·6	20	10	8	6·3
50	2·0	25	12·5	10	8
63	2·5	32	16	12·5	10
80	3·2	40	20	16	12·5
100	4·0	50	25	20	16
125	5·0	63	32	25	20
160	6·0	80	40	32	25

All dimensions in millimetres.

FIG. 1 RECOMMENDED MARK FOR INDICATING PRESENCE OF ELECTRICAL EQUIPMENT

10.1.2 *Marking of Operating Devices* — All operating devices, such as pushbuttons, selector switches, etc, shall be clearly and permanently marked to identify their function.

10.1.3 *Marking of Apparatus and Terminals* — Apparatus and terminals to which cable connections are to be made at the time of installation or re-established after maintenance, attention shall be marked in a durable manner in accordance with the indications in the diagrams.

10.2 Operating Instructions and Diagrams — The operating instructions and diagrams to be supplied with the machine tool shall provide the user with the necessary information for the installation, operation and maintenance of the electrical equipment.

All symbols used in operating instructions, drawings and diagrams should be chosen from IS : 2032 (Parts VI and VII)-1965*.

The apparatus, terminals and wires shall be referenced in the same way on all the relevant documents.

The necessary informatio will vary with number and complexity of the electrical apparatus provided:

a) on simple equipment having only one motor, other than an electrical coolant pump, the diagrams normally furnished with the controlgear shall be considered satisfactory, provided the diagrams show all of the electrical apparatus on the equipment and enable the connection to the power circuit to be made.

b) on equipment having more than one motor, the manufacturer of the machine, or its seller, shall deliver with each machine two copies of the manual of operating instructions and diagrams. One of these two copies of this manual shall be inserted in a suitable pocket attached inside the electrical control panel enclosure.

This manual shall contain the following data:

1) Installation drawing,
2) Circuit or schematic diagram,
3) Sequence of operations,
4) Wiring diagram,

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*Graphical symbols used in electrotechnology:

Part VI Motor Starters
Part VII Switchgear and auxiliaries.

5) List of units in the equipment, and
6) Maintenance instructions (if necessary).

NOTE — For very complex equipment reference should be made to IS : 1356 Part II)*.

10.2.1 *Installation Drawing* — The installation drawing shall give all information necessary for the preliminary work for setting up the machine tool.

10.2.1.1 It shall clearly show the outline of the machine tool and the position of all the control apparatus. The position, size and, if not apparent from the rated current, the minimum cross section of cables to be installed on site, should be clearly indicated.

10.2.1.2 Where necessary, the size, purpose and location of any cable ducts to be provided in the foundations by the purchaser should also be detailed.

10.2.1.3 Where space is required for the removal or servicing of electrical equipment, this should also be shown.

10.2.2 *Circuit or Schematic (Elementary) Diagram* — The circuit or elementary diagram shall permit the understanding of the details of the operations performed by the machine tool. It shall show, by means of symbols, the installation and all the lines, particularly all the electrical connections concerned in the operation of the machine tool. They shall be shown in the condition they adopt when they are unenergized previous to the beginning of a cycle.

On the diagram, the power, control and signal circuit shall be indicated separately, as far as they are separate electrically.

10.2.3 *Sequence of Operations* — Detailed information should be given to allow the sequence of operations of the various parts, to be understood by reference to the circuit or schematic diagram.

Where the sequence of operations or other related data is programme-controlled, full information on the programming system should be provided.

This information is only required in the case of complex equipment.

10.2.4 *Wiring Diagram* — It shall give full information about the external connections of the whole electrical equipment of the machine tool.

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*Electrical equipment of machine tools: Part II Electrical equipment of machines used in large series production lines. (*Under preparation*).

If the equipment is designed for operation on various voltages, the wiring or connection diagram shall indicate the connections that are to be modified in order to pass from one voltage to another.

10.2.5 *Schedule of Electrical Equipment* — The schedule of electrical equipment is an index of all electrical apparatus, with the necessary data for ordering of spare parts.

10.2.6 *Maintenance Instructions* — Maintenance instruction should mention:

a) The schedule of preventive maintenance,
b) Instructions for maintenance work (if necessary), and
c) Instructions for adjustments (if necessary).

11. TESTS

11.0 The following test shall be conducted on all machine tools except on-load operating tests which should be performed on prototypes or on special machine tools or upon request by the purchaser.

11.1 Insulation Resistance Test — The insulation resistance measured with dc voltage of 500 V between each conductor of the main circuits, the individual conductors of the control circuits and earthed frame shall not be less than one megohm.

11.1.1 When the control circuits are not directly connected to the main circuits, separate tests shall be made between the main circuits and the earthed frame, between the main circuits and the control circuits, and between the control circuits and the earthed frame.

11.2 Voltage Test — All the equipment shall be subjected to a voltage test of one minute duration by applying a test voltage as defined below between the short-circuited conductors of the main circuits, including any control circuits directly connected to the mains circuits and the earthed frame.

The test voltage shall be equal to 85 percent of the lowest test voltage to which all components shall have already been tested before assembly on the machine, with a minimum of 1 500 V.

This voltage shall be supplied from a transformer with a rating of at least 500 VA.

Components which are not designed to withstand such high test voltages (rectifiers, capacitors, electronic apparatus, etc) shall be disconnected during the test.

Nevertheless, any radio interference capacitors fitted between parts normally alive and accessible metal parts shall not be disconnected and shall withstand the above test.

11.3 Resistance to Earth — It shall be tested that the resistance between the main earth terminal and any metallic parts of the machine containing electrical equipment does not exceed 0·1 ohm (*see* **7.1**).

11.4 Operating Test

11.4.1 *No-Load Operating Test* — With the electrical equipment normally energized within the prescribed condition (for example, maximum variation of supply voltage) it shall be proved that the operation of the electrical equipment is correct and that the sequence of operations is normal. In particular, the correct operation of the emergency stopping device shall be checked.

11.4.1.1 This test shall be performed on each machine tool.

11.4.2 *On-Load Operating Test* — When the machine tool operates under normal load, continuously or at the duty agreed to between the purchaser and the manufacturer, the temperature-rise of all equipment above the ambient temperature in which the machine is intended to operate should not exceed that permitted by the Indian Standards appropriate for the apparatus concerned.

The correct operation of all the equipment shall be proved and, in particular, that an interruption and restoration of power supply does not endanger personnel or adversely affect the equipment.

It shall be proved that the emergency stopping of motors under load by means of the stopping devices described in **4.3.3** occurs safely.

The on-load operating test shall only be performed on prototypes or on special machine tools, unless otherwise specified by the purchase

12. GENERAL INFORMATION TO BE GIVEN WITH ENQUIRY AND ORDER

12.1 The particulars required in Appendix A shall be provided by the purchaser if required by the supplier.

APPENDIX A

[*Clauses* 5.5 (b) *and* 12.1]

ENQUIRY FORM

The following information should be given to enable suitable electrical equipment to be supplied with the machine tool. Only exact answers should be given to help prevent error.

Name of Customer..

Tender/Order No. ....Dated...............................

Type of Machine Tool...

Relevant Clause in This Standard	Questions	1	2	3
4.2	For each source of supply required:			
	DC or AC			
	Rated voltage			
	No. of phases (if ac)			
	Frequency, Hz (if ac)			
4.2	If neutral conductor is brought with the power supply ?...Yes/No			
4.2	If neutral is earthed ?...............................Yes/No			
4.1	Anticipated normal limits of supply variation if more than ±5 percent...............................			
4.4.4.2	If control circuit voltage not obtained directly from the power supply, control circuit voltage (and frequency if ac) to be used .... volts, ...Hz.			
9.1	If lighting circuit voltage not obtained directly from the power supply, lighting circuit voltage to be used, whether dc or ac and if so, frequency volts .... volts,....................Hz.			

RELEVANT CLAUSE IN THIS STANDARD	QUESTIONS
4.4.1.1	For what value of current or kVA is short-circuit protection to be provided (only if such protection is to be provided by the supplier of the machine tool) ? ....amperes ....kVA.
5.5	Limit of power up to which squirrel cage motors may be started directly across the line............................... ....kW.. NOTE — If the purchaser has any difficulty in completing the above questions, he should refer to his electricity supply authority.
1.1	Ambient conditions under which the machine tool is to be installed: Temperature climate................................... Tropical climate..
4.5.1.1	Is the place where the machine tool is to be installed Always dry.. Often damp... Occasionally damp.. Air-conditioned.. Maximum ambient temperature expected...........°C Minimum ambient temperature expected...........°C NOTE — If known please give maximum relative humidity at maximum and minimum temperatures and state whether such maximum relative humidity is frequently repeated or only occasional.
4.5.1.1	Will the air in the room in which the machine tool is to be installed be carrying any considerable quantity of dust ?......................Yes/No If dusty, is the dust metallic.. fibrous... inert and non-hygroscopic................... NOTE — Please state any other relevant ambient conditions.
10.2.1	Are any special arrangements for incoming cables to be supplied ?............................

RELEVANT CLAUSE IN THIS STANDARD	QUESTIONS
4.4.8	Are locks with detachable keys to be provided for fastening doors or covers ?......................Yes/No
4.4.7	Are three or two overload tripping devices to be supplied for three-phase motors ?..................Three/Two
4.4.2	Is it desired to provide a no-volt delay device to take care of short periods of voltage drop in supply system ?...... ....Yes/No
4.5.3	Are there any special limitations on the size or weight which may affect the transport of the particular machine or of control enclosure to site ?.................. ....Yes/No If so, maximum weight.. and maximum dimensions....................
5.1.3	In the case of machine tools with frequent repetitive cycles of operation, dependent on manual control, how often is it expected that such cycles of operation will be repeated (as a maximum)................per hour For what length of time is it expected that this maximum rate of repetition will be repeated without subsequent pause ? ....minutes
7.4	Is an earth leakage relay to be supplied ?..........Yes/No or an earth leakage relay to be connected instead of direct earthing ?.................Yes/No
11.4.2	In the case of specially built machine tools, is a certificate of on-load operating tests to be supplied ?............... ....Yes/No In the case of other machines, is a certificate of on-load operating tests on a prototype machine to be supplied ? ....Yes/No
12	Is the electrical equipment to comply wholly with this standard or are any modifications to be met ? If so, what ?.. ....

APPENDIX B

(*Clauses* 6.2.6.1 *and* 6.2.6.3)

SELECTION OF CABLES

Under Consideration.

BUREAU OF INDIAN STANDARDS

Headquarters :

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002
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331 13 75
371 94 02

Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices :	***Telephone***
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002	331 6617 335 3841
*Eastern : 1/14 CIT Scheme VII M, V.I.P. Road, Maniktola, CALCUTTA 700054	37 86 62
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Southern : C.I.T. Campus, IV Cross Road, MADRAS 600113	235 23 15
†Western : Manakalaya, E9 MIDC, Marol, Andheri (East), BOMBAY 400093	832 92 95
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‡Peenya Industrial Area, 1st Stage, Bangalore-Tumkur Road, BANGALORE 560058	839 49 55
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Plot No. 21 Satyanagar, BHUBANESHWAR 751007	40 36 27
Kalaikathir Building, 6/48 Avanashi Road, COIMBATORE 641037	21 01 41
Plot No. 43, Sector 16 A, Mathura Road, FARIDABAD 121001	8-28 88 01
Savitri Complex, 116 G.T. Road, GHAZIABAD 201001	8-71 19 96
53/5 Ward No. 29, R.G. Barua Road, 5th By-lane, GUWAHATI 781003	54 11 37
5-8-56C L.N. Gupta Marg, Nampally Station Road, HYDERABAD 500001	20 10 83
R 14, Yudhister Marg, C Scheme, JAIPUR 302005	38 13 74
117/418 B Sarvodaya Nagar, KANPUR 208005	21 68 76
Seth Bhawan, 2nd Floor, Behind Leela Cinema, Naval Kishore Road, LUCKNOW 226001	23 89 23
Patliputra Industrial Estate, PATNA 800013	26 23 05
T.C. No. 14/1421, University P.O., Palayam, THIRUVANANTHAPURAM 695034	6 21 17
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